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SEISMIC SAFETY ELEMENT

GRIDLEY GENERAL PLAN

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City Council
of the
City of Gridley
Gridley, California

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I. INTRODUCTION

Following the disastrous effects of the San Fernando earthquake in 1971, the California State Legislature mandated that all General Plans shall include a Seismic Safety Element:

> "consisting of an identification and an appraisal of seismic hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failures, or to effects of seismically induced waves such as tsunamis and seiches".*

The effect of this element is to require cities and counties to make seismic and geologic hazards a consideration of their local planning programs. The basic objective is to reduce loss of life, injuries, damage to property, and the economic and social dislocations resulting from future earthquakes. Essentially, it is the goal of the element to advocate the adoption of preventive measures before an earthquake occurs.

Prior to this requirement, many of the states local jurisdictions paid little attention to seismic activity in evaluating existing and proposed development. Concern was generally limited to the requirements of the building code or to the obvious seismic hazards of the area. Unfortunately, many jurisdictions still do not have the resources or the expertise available to administer an on-going seismic evaluation program.

It should be emphasized, that seismic activity is

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* Government Code, Section 65302(f).

regional in nature, in that what happens in one place may also affect an area several hundred miles away. Proper planning should incorporate seismic performance standards on a regional basis with special emphasis given to local issues by the local agency.

Current seismic information is based on what is observed of the present lay of the land, what man knows about geologic processes and from what has been encountered since the recorded occupation of the area. Existing information, for instance, does not tell us what lies under the alluvium of the Great Valley nor does it tell us when and where the next earthquake will occur. What we do know, is that California has had a historical and active pattern of earthquake activity up to the present time.

Through the adoption of a Seismic Safety Element, the City of Gridley will incorporate the potential seismic hazard as is known at this time into its planning program in an effort to minimize to an acceptable level the possible harmful effects of earthquakes and other geologic hazards upon the community. The element will also aid in identifying those areas which require further study and evaluation. Continual review of the element will be necessary as new information becomes available or new techniques are developed.

II. TYPES OF SEISMIC HAZARD

Primary attention of this element is directed towards those geological hazards which occur or can occur as the result of earthquake activity. Most of them are directly related to earthquake activity in that the earthquake is the precipitating agent, whereas others may occur independently of an earthquake for other reasons. The State of California has delineated five major areas of critical seismic concern which shall be considered by the element. These include:

1. Surface ruptures
2. Ground shaking
3. Ground failure
4. Tsunamis
5. Seiches

All of these seismic hazards have a common denominator in that they have the potential to cause loss of life or damage to property.

The essential ingredient of seismic activity is the earthquake. Earthquakes occur on fault lines in the earth's crust. They are the primary agent for seismic activity and vary in intensity, location, magnitude, and duration, etc. Their effects may be felt either locally or regionally.

An earthquake occurs when there is a rupture or rock or breakage of earth material on opposites of a fault as a result of accumulation of stress in the material. This movement or breakage releases energy which moves outward from the epicenter in the form of seismic waves.

These seismic waves do not disperse in a uniform pattern. They travel at different rates of speed depending upon the type of material they are passing through. Generally, the more solid or dense the material, the less susceptible it is to seismic waves. Conversely, the alluvium of the Great

Valley would be highly conductive to seismic wave passage due to its loose unconsolidated nature.

Within the State of California, there are many faults that have been identified which have the potential for earthquake activity. Identification has been mainly by two methods: observing the resultant land forms or from historical records. However, most faults within the state are considered to have had no recent activity.

For the purposes of the seismic element, the State suggests that faults be classified into two classes, active or inactive. Broader classifications should be based on the type of land use contemplated or on the criticality of the structures at issue. For instance, a dam would be a more critical structure than the conventional single family home.

An active fault is one that has moved in recent geologic time and which is likely to move again in the relatively near future. An inactive fault is one which shows no evidence of movement in recent geologic time and shows no evidence of movement in the relatively near future.

Fault Displacement

Fault displacement occurs when the earth on one side of a fault line moves in relation to the earth on the other side of the fault line. Displacement may be as little as several inchs to many feet. Movement may occur in several directions which have been classified as: right-lateral, left-lateral, reverse, normal or oblique slip. If movement is some distance below the earths's surface, displacement may not be evident at the surface.

Surface Rupture

Surface rupture is fault displacement which is manifested on the surface of the earth. Its effects may also be felt below the surface with changes in water table or strata. Most, if not all, major California earthquakes have been accompanied by some degree of surface rupture. Surface faulting can result in scarps, grabens, fractures, and pressures ridges. Surface rupture is important to planning in that structures built

across fault lines may be torn apart or otherwise destroyed when a surface rupture occurs underneath or immediately adjacent to the structure.

<u>Ground Shaking</u>

Ground shaking is the oscillation or vibration of earth materials resulting from an earthquake. It is the most commonly experienced earthquake phenomenon because it may be felt at some distance from the epicenter. Ground shaking has the greatest impact on areas underlaid by loose, water saturated, thick sediments such as those located within the planning area during the wet season.

Damage from ground shaking is caused by the transmission of earthquake vibrations from the ground into building structures. The resultant damage is related to structural design, type of construction, and the intensity, period, and duration of the ground motion.

Ground shaking has been the dominant form of seismic activity affecting the planning area. The effects of ground motion are measured by the intensity of the motion felt (Modified Mercalli Scale, Appendix A), whereas magnitude measures the amount of energy released when an earthquake occurs.

<u>Ground Failure</u>

Ground failure occurs when the stresses in the ground exceed the resistance of earth materials to deformation or rupture. Instability comes about when stresses are increased by natural or man-made causes, such as by earthquakes, fills, and ground water withdrawal.

1. Liquefaction - is the process, whereby water in unconsolidated sand and other granular materials is subjected to pressure usually caused by ground motion. The earthquake induced deformation transforms a stable granular material into a fluid in which the solid particles are in a virtual state of

suspension, similar to quicksand. The effect is that ground literally flows out from under building.

2. Lateral spreading - is the squeezing of soft, saturated clays, which results in a rapid or gradual loss of strength in the foundation materials, so that structures built upon them gradually settle or breakup as the soil flows out laterally.
3. Earth lurching - is the movement of the land at right angles to a vertical surface. This can result in the formation of cracks in the ground caused by the ground being thrown into undulating waves.
4. Landslides - do not necessarily require a steep slope on which to occur, particularly during earthquakes. Landslides can occur on slopes that are virtually flat and in soil depths ranging from a few feet to several hundred feet. Slippage may also occur on subsurface inclines.
5. Differential settlement - is the non-uniform compaction of loose granular soils which has the water in it freed by liquefaction and forced to the surface. As the water is removed from the subsurface, the ground settles. Differential settlement may also occur through simple compaction of areas underlaid by sand or in fill areas in former sloughs and streams.
6. Subsidence - occurs usually in areas where there has been withdrawal of subsurface fluids over a long period of time. Normally, subsidence covers extensive areas as a result of activity by man.
7. Erosion - is the wear and removal of material from one site and its deposition in another.

Tsunamis

Tsunamis are commonly called "tidal waves". Tsunamis are long period waterwaves that are seismically or tectonically induced in the oceans. Their principal impact is felt by coastal areas

Seiches

Seiches are periodic oscillations of water levels in basins that occur as the result of wind and weather changes, landslides, and tectonic activity. Seiches may occur in harbors, bays, rivers, or other bodies of water.

III. EVALUATION OF LOCAL SEISMIC HAZARD

Historically, very little seismic activity has occurred in the Gridley planning area as compared to other parts of California. The main recent geologic process within the area has been one of deposition of sediments from the surrounding highlands into the valley.

In a study prepared by Guyton and Scheel in 1974, Earthquake Hazard of Northeastern California, it was determined that for the last 120 years there have been only 295 earthquakes recorded within the thirteen counties of northeastern California. Of these, only nineteen were recorded within Butte County. It was estimated from the scant data available, that none of the earthquakes originating within this region produced a magnitude greater than 6.5 on the Richter scale (See Figure 1).

Of the intensities reached within the region, 22 reached an intensity of VI or greater, ten reached VII or higher, and one may have reached a maximum intensity of VIII. Ninty percent of the earthquakes recorded within the region were of intensity less than V. Within Butte County, six of the recorded earthquakes reached intensities of VI or greater.

Earthquakes originating outside of the thirteen county region have not had an effect greater than those earthquakes produced within the region. For instance, the Owens Valley earthquake of 1872, reached a maximum intensity of V in Chico. The San Francisco earthquake of 1906 may have also reached an intensity of V within the planning area (See Figure 2).

The California Division of Mines and Geology in their bulletin, Urban Geology Master Plan for California, locate the Gridley planning area on the boundary between the low and moderate earthquake severity zones. Within the low severity zone, maximum earthquake intensites of VI and VII can be expected. In the moderate zone, maximum probable earthquake intensites may reach VII or VIII (See Figure III).

Guyton and Scheel conclude from their study of recorded earthquake activity in northeastern California that "planning

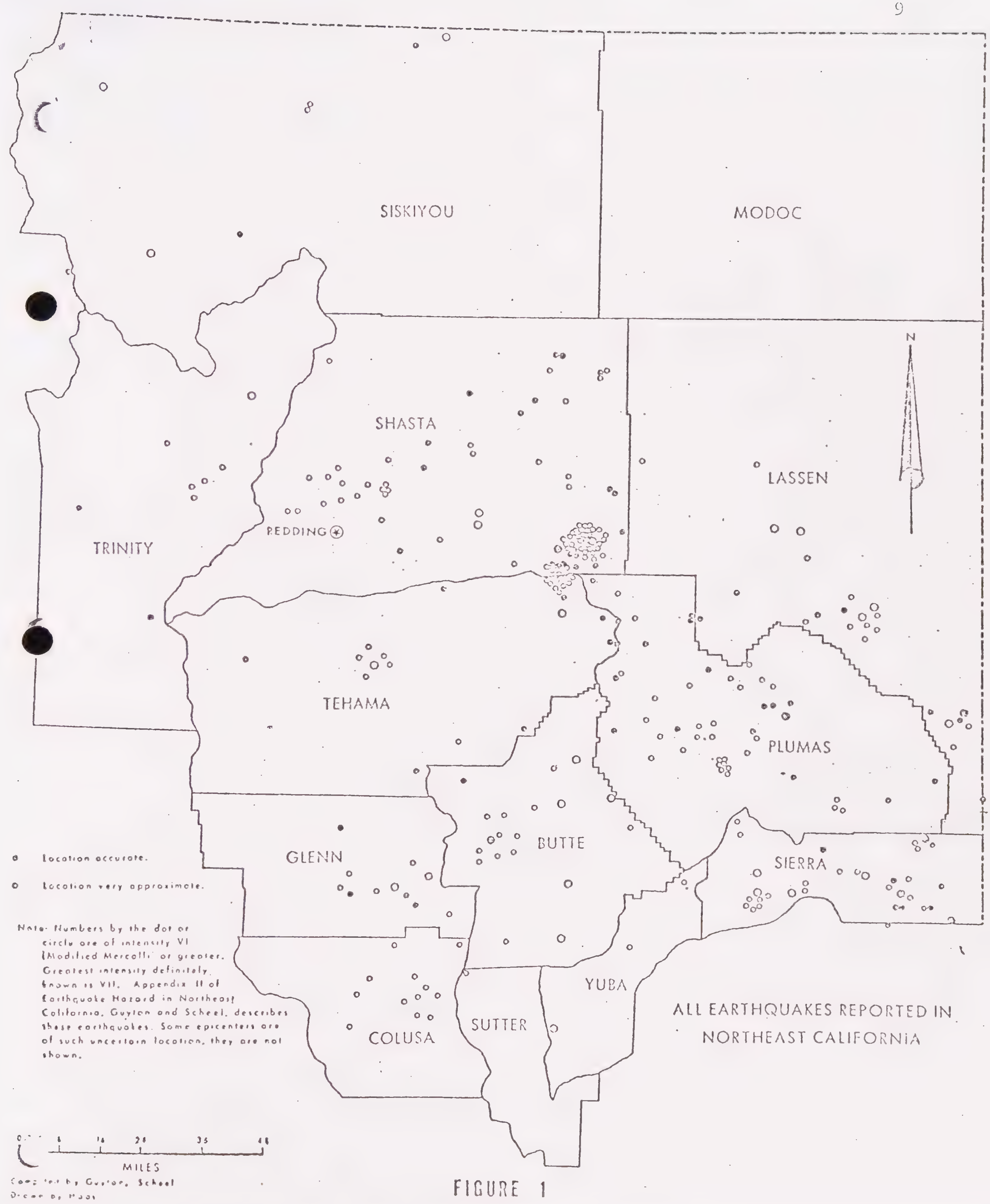

SISKIYOU
MODOC
SHASTA
LASSEN
REDDING
TRINITY
TEHAMA
PLUMAS
BUTTE
GLENN
SIERRA
YUBA
SUTTER
COLUSA
N
Location accurate.
Location very approximate.
Note: Numbers by the dot or circle are of intensity VI (Modified Mercalli) or greater. Greatest intensity definitely known is VII. Appendix II of Earthquake Hazard in Northeast California, Guyton and Scheel, describes these earthquakes. Some epicenters are of such uncertain location, they are not shown.
ALL EARTHQUAKES REPORTED IN NORTHEAST CALIFORNIA
MILES

FIGURE 1

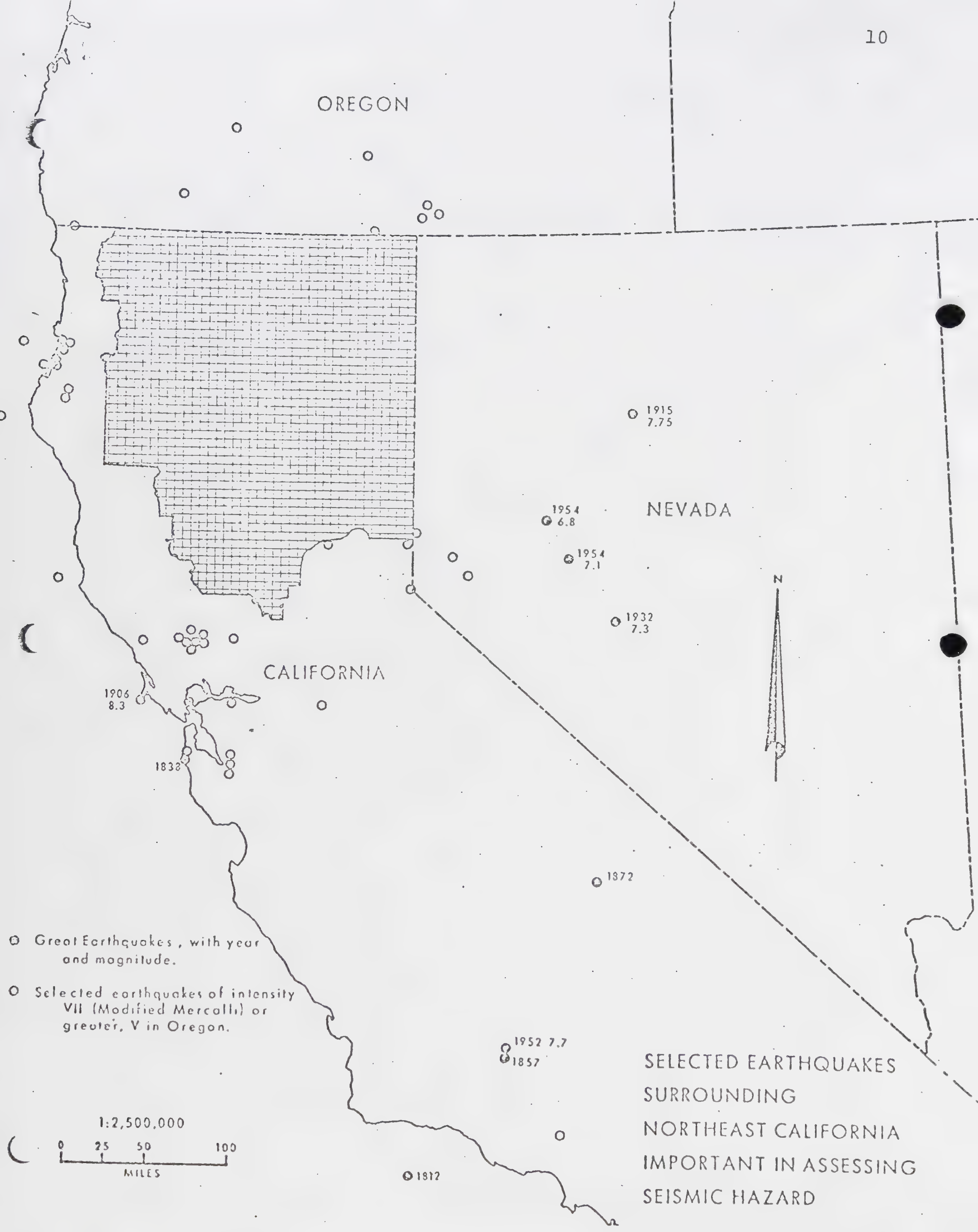
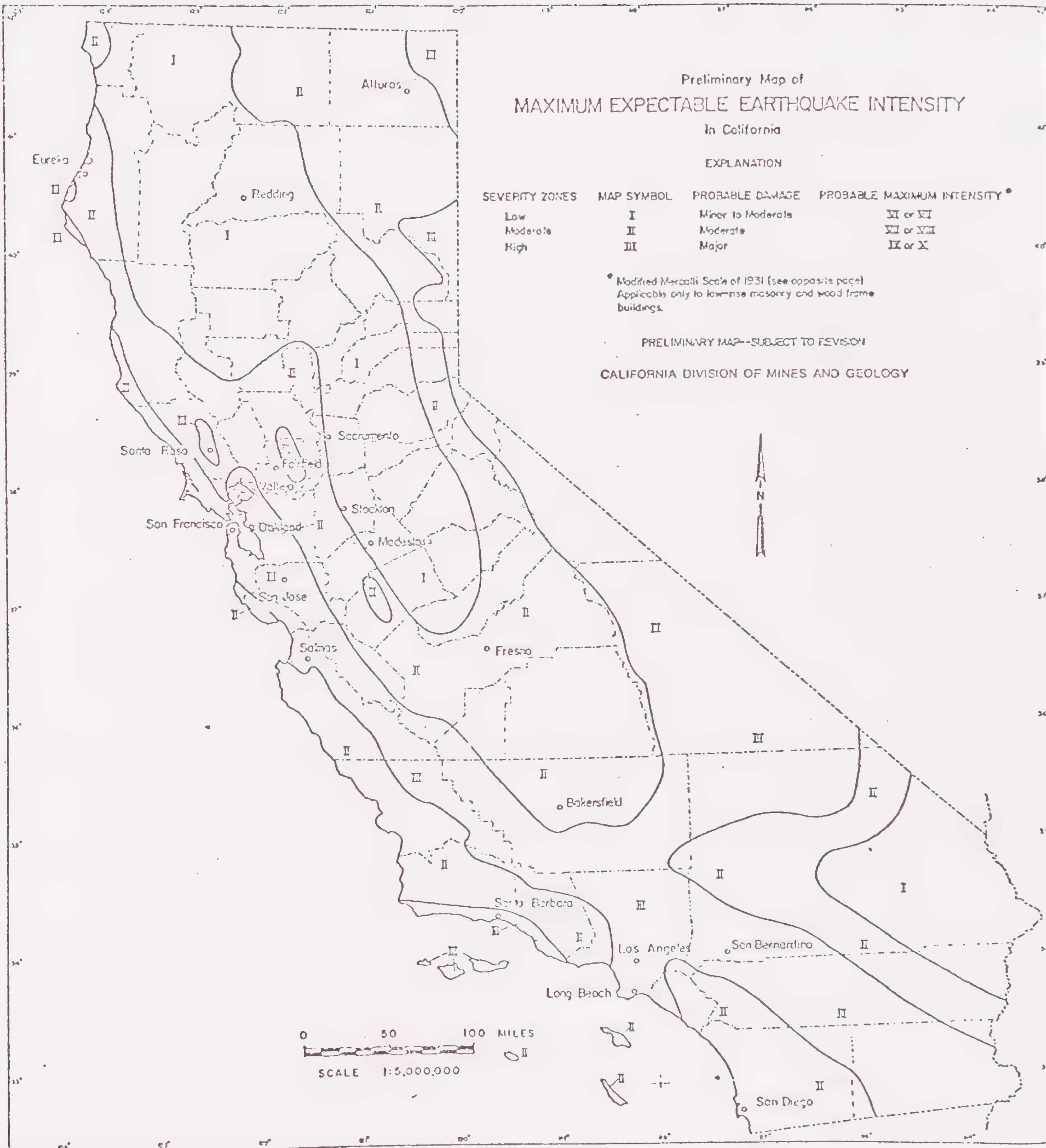

OREGON
NEVADA
CALIFORNIA
1915 7.75
1954 6.8
1954 7.1
1932 7.3
N
1906 8.3
1838
1872
1952 7.7
1857
1812
Great Earthquakes, with year and magnitude.
Selected earthquakes of intensity VII (Modified Mercalli) or greater, V in Oregon.
1:2,500,000
0 25 50 100
MILES
SELECTED EARTHQUAKES SURROUNDING NORTHEAST CALIFORNIA IMPORTANT IN ASSESSING SEISMIC HAZARD
Compiled by Guyton, Scheel
Drawn by Hoos

FIGURE 2



Source: California Division of Mines and Geology

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FIGURE 3

within the region should be based on a maximum intensity of VIII". This recommendation is in line with the Division of Mines and Geology projections. Therefore, prudent planning would use an intensity of VIII as the maximum expected earthquake intensity which could be expected to occur.

Intensity of an earthquake is of more practical use to the planner in that it is a measure of the strength of an earthquake and its effects upon people, buildings and objects, whereas, magnitude is the measure of the amount of energy released by an earthquake, but not its impact. One other consideration is the maximum probable ground acceleration that an earthquake can produce.

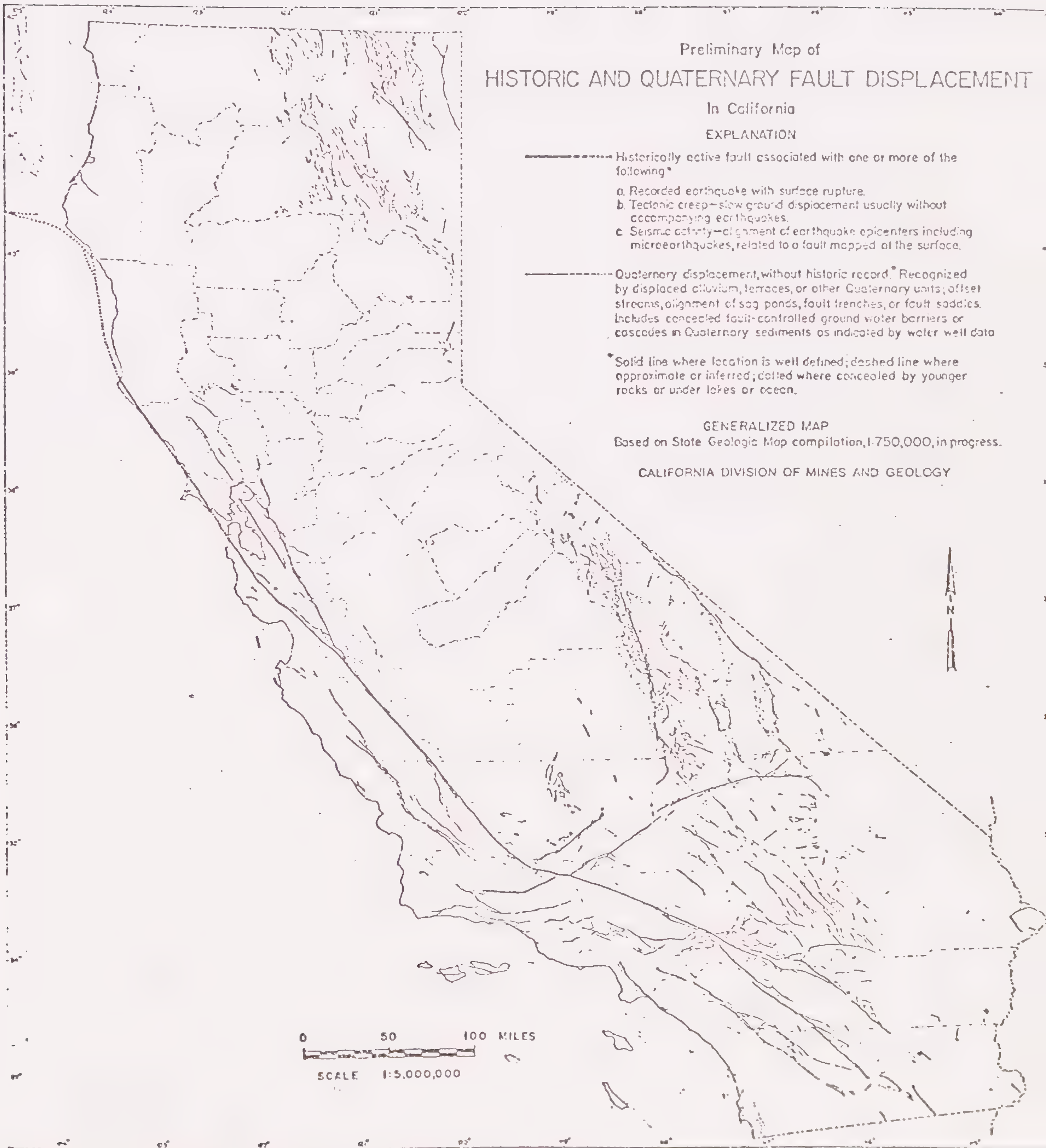
In a study prepared for the State Department of Water Resources by Bay-Valley Consultants, Recommended Water Quality Management Plan, the maximum probable bedrock accelerations for the Gridley area are estimated to range from less than 0.1 g to no more than 0.3 g. The reason for the range is that again the planning area is astride the boundary line of Seismic Zone 1 and Seismic Zone 2.

The evaluation of the hazards of seismic activity in the planning area and for Butte County as a whole requires the development of substantial amounts of geologic and seismic data and its interpretation. Some of this data has already been developed, but it is of only general and limited scope. For example, area soil surveys are addressed to the suitability of the soil for agriculture and not for urban development. It is imperative that basic seismic data be acquired on a regional basis with specific studies being made on the local level.

Fault Displacement

Within the planning area there are no earthquake faults known to exist at this time, although, subsurface concealed faults may exist. However, for purposes of this element they have not been taken into consideration.

The nearest active faults to the planning area are located in Sierra, Plumas, Lassen and Yolo counties. Figure 4 shows



Source: California Division of Mines and Geology

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FIGURE 4

a preliminary map prepared by the Division of Mines and Geology which shows no active faults in Butte County, although, there are several inactive ones.

The effects of fault displacement are not expected to be directly felt within the planning, although the associated secondary effects such as ground shaking will be a factor.

<u>Surface Ruptures</u>

With the present level of information, surface ruptures associated with fault displacement are not expected to occur within the planning area.

<u>Ground Shaking</u>

Most of the seismic damage expected to occur within the planning area will be as a result of ground shaking. Maximum probable intensities that are expected to develop may reach as high as VIII. It is recommended that intensity VIII, therefore, be the design level for critical structures or uses. Guyton and Scheel in analyzing their information report that historical damage that has occurred within the thirteen north-eastern California counties has been minor in nature, consisting of damage to chimmeys, windows and minor wall movements.

<u>Ground Failure</u>

1. Liquefaction - There are no reported cases of liquefaction within the planning area, however, the potential does exist for occurrence, especially during the wet season when the alluvial soils can become saturated.
2. Lateral spreading - Again, there are no reported cases of lateral spreading within the planning area. Development on clay soils within the planning area should be analyzed for possibility of occurrence.
3. Earth lurching - It is expected that minor earth lurching has occurred in the past. A severe earthquake in the future could induce this hazard.

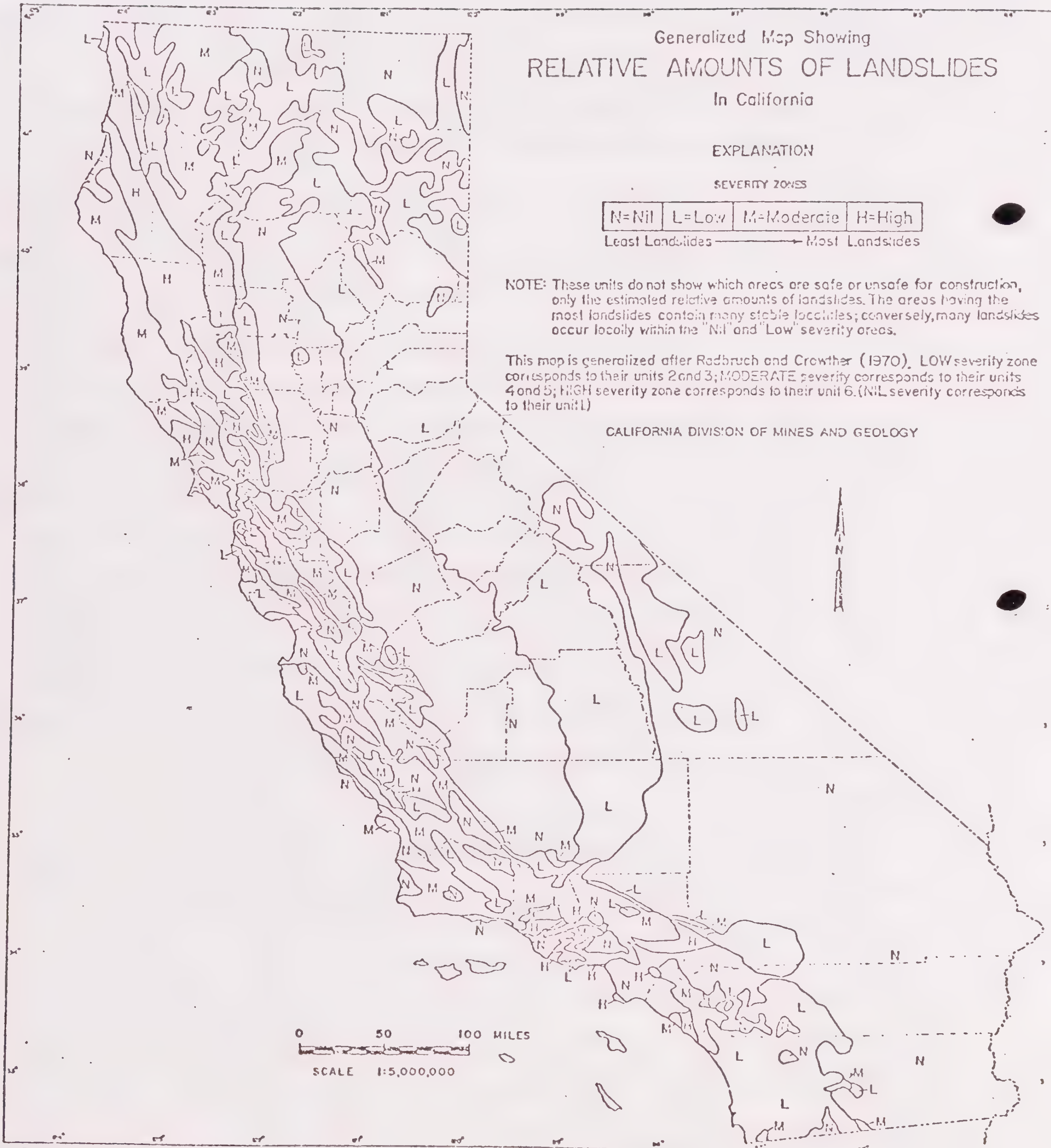
4. Landslides - There are no reported landslide events in the area due to the low level of relief. The Division of Mines and Geology rates the area as having a nil potential for this hazard (see Figure 5).
5. Differential settlement - Again, there are no reported cases of this event, however, development over filled-in sloughs or ditches should be engineered to alleviate this problem.
6. Subsidence - There are no reports of a real subsidence occurring within the planning area on a large scale. However, if significant amounts of fluids were removed from the basin, it might possibly become a problem. Figure 6 indicates that subsidence is not expected to occur within the planning area.
7. Erosion - There is no serious erosion problem of critical nature occurring in the area, and none is expected to take place, providing adequate grading and farming methods are utilized.

Tsunamis

Due to the planning area's distance from the Pacific Ocean, there is not expected to be any hazard from tsunamis.

Seiches

Seiches may possibly be a problem within the area when caused by seismic activity. Water may be spilled from irrigation canals, the Feather River or reservoirs. The time of the year of the event will have a significant effect on the damage potential of the event. Flood inundation maps being prepared for Lake Oroville showing areas of potential flooding in the event of a total or partial failure of Oroville Dam should be analyzed when completed for possible danger to the planning area.



Source: California Division of Mines and Geology

FIGURE 5

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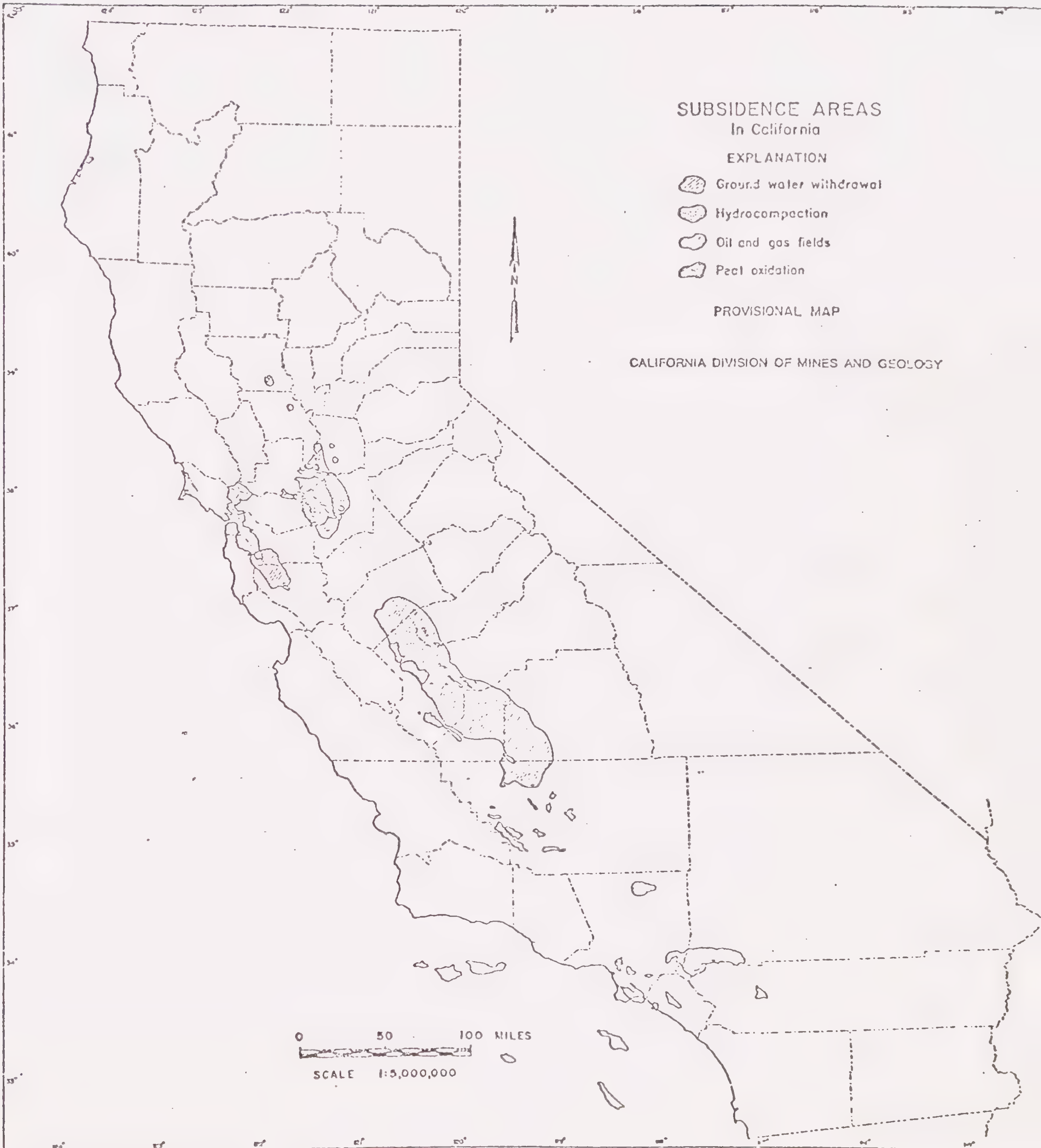

Source: California Division of Mines and Geology

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FIGURE 6

IV. STANDARDS

Since it is the intent of the element to make the community aware of its seismic hazards and to advocate measures for reducing these dangers to the lowest practical level, the following standards are adopted by the community for consideration of existing and proposed development:

1. Reduce the risk of loss of life and damage to property to the lowest acceptable level.
2. Insure that essential community facilities will remain operational during the maximum probable earthquake event, including:
   a. Emergency facilities
   b. Utilities
   c. Communications and transportation routes
   d. Water retention structures
3. Require that high occupancy structures be able to withstand the maximum probable event.

V. RECOMMENDATIONS

It is suggested that the City of Gridley adopt the following recommendations in order to mitigate the possible seismic hazards which may occur within the area:

1. Require that the design level for all essential community facilities and large occupancy buildings be no less than intensity VIII, the maximum probable event.
2. Amend the subdivision ordinance in order to require geologic and soil reports.
3. Adopt the 1973 edition of the Uniform Building Code.
4. Undertake or support studies which will aid in determining seismic hazard.
5. Inspect all large occupancy buildings constructed prior to 1933 for structural stability, and formulate an abatement program.
6. Adopt a parapet and appendages ordinances.

Adoption of the 1973 Uniform Building Code requires that all facilities constructed will meet the standards of Seismic Zone III requirements within the planning area. If the above measures are implemented, the community will develop in a manner of a reasonable level of acceptable seismic risk.

APPENDIX A

MODIFIED - MERCALLI INTENSITY SCALE

I. Not felt by people, except under especially favorable circumstances. However, dizziness or nausea may be experienced.

Sometimes birds and animals are uneasy or disturbed. Trees, structures, liquids, bodies of water may sway gently, and doors may swing very slowly.

II. Felt indoors by a few people, especially on upper floors of multi-story buildings, and by sensitive or nervous persons.

As in Grade I, birds and animals are disturbed, and trees, structures, liquids and bodies of water may sway. Hanging objects swing, especially if they are delicately suspended.

III. Felt indoors by several people, usually as a rapid vibration that may not be recognized as an earthquake at first. Vibration is similar to that due to passing of a light, or lightly loaded trucks, or heavy trucks some distance away. Duration may be estimated in some cases.

Movements may be appreciable on upper levels of tall structures. Standing motor cars may rock slightly.

IV. Felt indoors by many, outdoors by few. Awakens a few individuals, particularly light sleepers, but frightens no one except those apprehensive from previous experience. Vibration like that due to passing of heavy, or heavily loaded trucks. Sensation like a heavy body striking building, or the falling of heavy objects inside.

Dishes, windows and doors rattle; glassware and crockery clink and clash. Walls and house frames creak, especially if intensity is in the upper range of this grade. Hanging objects often swing. Liquids in open vessels are disturbed slightly. Stationary automobiles rock noticeably.

V. Felt indoors by practically everyone, outdoors by most people. Direction can often be estimated by those outdoors. Awakens many, or most sleepers. Frightens a few people, with slight excitement; some persons run outdoors.

Buildings tremble throughout. Dishes and glassware break to some extent. Windows crack in some cases, but not generally. Vases and small or unstable objects overturn in many instances, and a few fall. Hanging objects and doors swing generally or considerably. Pictures knock against walls, or swing out of place. Doors and shutters open or close abruptly. Pendulum clocks stop, or run fast or slow. Small objects move, and furnishings may shift to a slight extent. Small amounts of liquids spill from well-filled open containers. Trees and bushes shake slightly.

APPENDIX A

MODIFIED - MERCALLI INTENSITY SCALE

(continued)

VI. Felt by everyone, indoors and outdoors. Awakens all sleepers. Frightens many people; general excitement, and some persons run outdoors.

Persons move unsteadily. Trees and bushes shake slightly to moderately. Liquids are set in strong motion. Small bells in churches and schools ring. Poorly built buildings may be damaged. Plaster falls in small amounts. Other plaster cracks somewhat. Many dishes and glasses, and a few windows, break. Knickknacks, books and pictures fall. Furniture overturns in many instances. Heavy furnishings move.

VII. Frightens everyone. General alarm, and everyone runs outdoors.

People find it difficult to stand. Persons driving cars notice shaking. Trees and bushes shake moderately to strongly. Waves form on ponds, lakes and streams. Water is muddied. Gravel or sand stream banks cave in. Large church bells ring. Suspended objects quiver. Damage is negligible in buildings of good design and construction; slight to moderate in well-built ordinary buildings; considerable in poorly built or badly designed buildings, adobe houses, old walls (especially where laid up without mortar), spires, etc. Plaster and some stucco fall. Many windows and some furniture break. Loosened brickwork and tiles shake down. Weak chimneys break at the roofline. Cornices fall from towers and high buildings. Bricks and stones are dislodged. Heavy furniture overturns. Concrete irrigation ditches are considerably damaged.

VIII. General fright, and alarm approaches panic.

Persons driving cars are disturbed. Trees shake strongly, and branches and trunks break off (especially palm trees). Sand and mud erupt in small amounts. Flow of springs and wells is temporarily and sometimes permanently changed. Dry wells renew flow. Temperature of spring and well waters varies. Damage slight in brick structures built especially to withstand earthquakes; considerable in ordinary substantial buildings, with some partial collapse; heavy in some wooden houses, with some tumbling down. Panel walls break away in frame structures. Decayed pilings break off. Walls fall. Solid stone walls crack and break seriously. Wet ground and steep slopes crack to some extent. Chimneys, columns, monuments and factory stacks and towers twist and fall. Very heavy furniture moves conspicuously or overturns.

IX. Panic is general.

Ground cracks conspicuously. Damage is considerable in masonry structures built especially to withstand earthquakes; great in other

APPENDIX A

MODIFIED - MERCALLI INTENSITY SCALE

(continued)

masonry buildings--some collapse in large part. Some wood frame houses built especially to withstand earthquakes are thrown out of plumb, others are shifted wholly off foundations. Reservoirs are seriously damaged and underground pipes sometimes break.

X. Panic is general.

Ground, especially when loose and wet, cracks up to widths of several inches; fissures up to a yard in width run parallel to canal and stream banks. Landsliding is considerable from river banks and steep coasts. Sand and mud shifts horizontally on beaches and flat land. Water level changes in wells. Water is thrown on banks of canals, lakes, rivers, etc. Dams, dikes, embankments are seriously damaged. Well-built wooden structures and bridges are severely damaged, and some collapse. Dangerous cracks develop in excellent brick walls. Most masonry and frame structures, and their foundations, are destroyed. Railroad rails bend slightly. Pipe lines buried in earth tear apart or are crushed endwise. Open cracks and broad wavy folds open in cement pavements and asphalt road surfaces.

XI. Panic is general.

Disturbances in ground are many and widespread, varying with the ground material. Broad fissures, earth slumps, and land slips develop in soft, wet ground. Water charged with sand and mud is ejected in large amounts. Sea waves of significant magnitude may develop. Damage is severe to wood frame structures, especially near shock centers; great to dams, dikes and embankments, even at long distances. Few if any masonry structures remain standing. Supporting piers or pillars of large, well-built bridges are wrecked. Wooden bridges that "give" are less affected. Railroad rails bend greatly, and some thrust endwise. Pipe lines buried in earth are put completely out of service.

XII. Panic is general.

Damage is total, and practically all works of construction are damaged greatly or destroyed. Disturbances in the ground are great and varied, and numerous shearing cracks develop. Landslides, rock falls, and slumps in river banks are numerous and extensive. Large rock masses are wrenched loose and torn off. Fault slips develop in firm rock, and horizontal and vertical offset displacements are notable. Water channels, both surface and underground, are disturbed and modified greatly. Lakes are dammed, new waterfalls are produced, rivers are deflected, etc. Surface waves are seen on ground surfaces. Lines of sight and level are distorted. Objects are thrown upward into the air.

Source: Planning Commission Subcommittee on Land Use and Development Regulations, Hayward Earthquake Study, April, 1972

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